METHOD AND APPARATUS FOR SELECTING REGIONS OF INTEREST IN OPTICAL IMAGING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35USC§119(e) of US patent application serial number 10/317,857 filed December 12, 2002 the petition to convert to a provisional patent application in accordance with 35USC§111(b)(6) and 37CFR1.53(c)(2) being filed concurrently herewith. This application is related to commonly assigned co-pending US patent application (bearing agent docket number 15186-32US) filed simultaneously herewith, the specification of which is hereby incorporated by reference.

TECHNICAL FIELD

[0002] The invention relates to the field of optical imaging and more specifically to the field of selecting regions of interest in a subject for optical imaging.

BACKGROUND OF THE INVENTION

[0003] Optical imaging has evolved to become a useful diagnostic tool. Various system designs have been developed to accommodate imaging of various parts of the human body. For example, Hillman et al. (Phys. Med. Biol, 46 (2001)1117-1130) describes an arrangement for acquiring optical signals from a forearm; and Pogue et al. (Opt. Express 1 (1997) 391-403) describes a system for breast imaging. Optical imaging systems have also been developed for small mammals with a view of providing a research tool that can image changes in the physiology of the mammals and that can also provide information on the biodistribution molecules such as chromophores and fluorophores. An example of an optical imaging system for small mammals has been described in patent application WO 0137195.

[0004] Diagnosis as well as physiological and pharmacokinetics studies rely on time course protocols to reveal temporal changes within a subject with respect to

predetermined characteristics. Thus, a suitable imaging tool should be able to reliably and reproducibly produce images of the same region of interest in a subject over time. In this respect accurate and reproducible positioning of the subject relative to the imaging optics is very important.

[0005] While the above mentioned optical imaging systems permit the repositioning of a subject in more or less the same position over several imaging sessions, they lack a positioning system that is reliable and precise. Thus there is a need for improved systems and methods for selecting regions of interest in a subject and reproducibly image the selected regions over time.

SUMMARY OF THE INVENTION

[0006] The present invention provides a system and method for selecting regions of interest (ROIs) in a subject such as a mammal and for reproducibly positioning the subject to image the same ROIs over time.

[0007] In one aspect of the invention there is provided a method for positioning a small mammal such as a mouse for optical imaging in which a digital image of the mammal is obtained and used to define a ROI by placing the mammal in the field of view of a camera. The ROI is then registered with an optical imaging system and the mammal is positioned relative to the imaging system in accordance with the coordinates of the ROI.

[0008] In an embodiment of the method, the ROI is selected by determining the contour of the ROI on a computer displayed image of a surface comprising the ROI.

[0009] In yet another aspect, a second digital image may be obtained to determine a plane at which the imaging system is focused for acquiring optical data when using an optical system in which light is propagated through air and wherein the optical signal is collected using lenses.

[0010] In yet another embodiment of the method, fiducial marks are inscribed on the subject and can be used as a reference for reproducible positioning of the subject and for selecting the same ROI over time.

[0011] In another aspect of the invention there is also provided a method for positioning a mammal for optical imaging which comprise determining a 3 Dimensional (3 D) contour of at least the part of the animal comprising the ROI and using the 3 D contour information in image reconstruction of the ROI.

[0012] The invention also provides a system for positioning a subject comprising a mammal supporting means, a camera for imaging a surface of the mammal comprising a ROI, storage means for storing the digital image, a display operationally linked to the storage means for displaying the stored digital image, a user interface to define the ROI, and a registering means for registering the defined ROI with an optical imaging system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Further features and advantages of the present invention will become apparent from the following detailed description, taken in combination with the appended drawings, in which:

[0014] FIG. 1 is a perspective representation of an embodiment of an optical imaging system comprising a system for positioning a mammal in accordance with the invention;

[0015] FIG. 2 is a computer display illustrating an embodiment of the selection of a region of interest; and

[0016] FIG. 3 is a computer display illustrating the selection of a plane of optical data acquisition according to an embodiment of the invention.

[0017] It will be noted that throughout the appended drawings, like features are identified by like reference numerals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] The present invention provides a system and method for selecting regions of interest (ROIs) for optical imaging in a subject such as a mammal and for reproducibly positioning the subject to image the same ROIs over time.

[0019] In accordance with one embodiment of the invention, a system for positioning a mammal or part thereof for optical imaging of a ROI of the mammal is provided, which allows the user to select a ROI of the mammal and register the coordinates of the selected region with an optical imaging system. This greatly facilitates manipulation of the mammal with a view of acquiring precise and reproducible optical images. In addition, the system in accordance with the invention permits the programming of the optical imaging system for automatic optical signal acquisition of the desired ROI. Furthermore, the coordinates of the ROI may be stored electronically for future retrieval and advantageously allowing the ROI to be repeatedly imaged over time, with a high degree of reproducibility. This characteristic enables time course experiments to be carried out on mammals by, for example, enabling pharmacokinetic studies, assessment of tumor growth and the like.

[0020] FIG. 1 illustrates an embodiment of an optical imaging system comprising a system for positioning the mammal 10. In one embodiment, the system comprises a camera 12, a support 14 for the mammal, and a computer 16 operationally linked to the camera and the optical imaging system.

[0021] The mammal support is preferably a heated tray, and is preferably made of non-reflective substance, that can be moved relative to the optical imaging system. This can be achieved by providing a translation stage 18 on which the tray is mounted. In addition to the motion along the translational stage axis, the tray

may also be moved up and down to place the animal in the object plane of the imaging optics. The computer may be coupled to the tray in order to provide the user with a means for remotely controlling the position of the tray. Preferably the animal is anesthetized to prevent it from moving during image acquisition. In this respect, the tray may comprise a mask and/or tubes coupled to an anesthetic supply to provide anesthetic to the animal while it is being imaged. The tray may also comprise a sensor in order to monitor animal movement during data acquisition. Advantageously the tray may also comprise physiological monitors such as electrocardiograph, temperature sensors, respiration monitors and the like.

[0022] The optical imaging system comprises a combination of mirrors 20 and lens 22 for directing the light source 23 onto the surface of the mammal, and a second set of mirror 24 and lenses 26 is provided for collecting and directing the light re-emitted from the mammal to a detector. The detector is in turn linked to the computer, where the acquired optical signals are processed for generating an image.

[0023] An embodiment of the method of the present invention is now described. First, a digital image of the surface of the mammal comprising the ROI is acquired by exposing the surface to the field of view of the camera 12. The digital image of the ROI permits the user to define the ROI and register the ROI with the optical imaging system as will be described below. Preferably the digital image is a live image and is continuously updated. Software instructions can then be used for proper positioning of the mammal relative to the optical imaging system in order to acquire the optical signals for image reconstruction. Acquisition of the image is preferably performed with the table at a predetermined position relative to the optical imaging system so as to provide an internal reference of coordinates.

[0024] Once the digital image has been acquired, the ROI may be defined by displaying the image of the surface comprising the ROI on a display screen 28 (FIG. 2). The user may then select the ROI 30 using a user interface drawing device, such as a mouse 17, for example. The selection of the ROI triggers the

computer to digitally record the coordinates of the ROI. The coordinates may be stored in a memory for later retrieval.

[0025]   The coordinates of the ROI are then used to program the optical imaging system to scan the region defined by the coordinates. This may be accomplished, for example, by programming the position of mirrors to direct the illumination beam and the optical signals re-emitted from the mammal to the appropriate location. In addition to defining the ROI, the user may also define the positions 32 within the ROI where the surface is to be illuminated by the beam of light, and the position where the optical signals re-emitted from the surface of the mammal are to be collected. Selection of illumination and detection points depends on the desired mode of optical imaging (continuous wave, time or frequency domain), the desired resolution, whether the image is topographic or tomographic and the like.

[0026]   In a further embodiment, the system may also comprise a second camera 34 located on a side of the apparatus so as to provide a field of view that is substantially perpendicular to the field of view of the camera used to acquire the digital image of the surface comprising the ROI. In optical imaging systems in which the light is propagated through air (i.e. through free space optics) and wherein light re-emitted from the mammal is collected with lenses, the second camera allows the acquisition of a digital image that can be used to set the height of the mammal relative to the object plane 36 of the collection optics (FIG. 3). Accordingly, the image acquired by the first camera may be stored in the computer and displayed on a screen, overlaid with the live video image, thereby enabling the user to re-align the mammal in a particular plane prior to subsequent scans. As for the selection of the ROI, the plane of imaging may be selected using a user interface device, such as a mouse, for example.

[0027]   The system may also comprise means to determine the volumetric profile of the animal. In one embodiment, the volumetric profile can be determined by scanning the animal with a laser beam directed substantially perpendicularly to the animal. By simultaneously acquiring an image of the laser beam at the surface of

the animal with a video camera placed at an angle to the laser path, the volumetric profile may be determined. The animal may be scanned by moving the tray. It will be appreciated that the volumetric profile thus obtained provides spatial information useful for image reconstruction and display.

[0028]   In a preferred embodiment, the cameras are located in a positioning chamber 38 optically insulated from the chamber 40 comprising the optical components by baffle 42. In this embodiment, the tray may be moved back and forth between the optical chamber and the positioning chamber by displacement on the translation stage which spans the two compartments. This permits the user to easily manipulate the mammal in the positioning chamber without interfering with or risking disturbing the various optical components.

[0029]   In another embodiment, fiducial marks may be inscribed on the mammal to provide references that can be used to select the region of interest when a plurality of optical images are acquired over time so that the same region of interest is selected and registered with the optical system. The fiducial marks may also be used for registering the optical images with another imaging modality such as computed tomography (CT), magnetic resonance imaging (MRI) and the like.

[0030]   The embodiment(s) of the invention described above is(are) intended to be exemplary only. The scope of the invention is therefore intended to be limited solely by the scope of the appended claims.